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LISTS OF SPECIES

Fish fauna of headwater streams of Perobas Biological Reserve, a conservation unit in the Atlantic Forest of the Northwestern Paraná State, Brazil

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ABSTRACT: The Perobas Biological Reserve is a Conservation Unit characterized by two physiognomies of the Atlantic Forest: Semideciduous Seasonal Forest and Mixed Ombrophilous Forest. The reserve is situated on a ridge watershed between the basins of the Piquiri and Ivaí rivers, Upper Paraná River and had its fish fauna surveyed for the first time. Fishes were collected quarterly from December 2010 to March 2012, using electrofishing in five stretches of 50 m along the four streams, and gillnets only at one site in December, 2010. A total of 2628 individual were collected, belonging to 34 species in 25 genera, 13 families and six orders. Ten taxa may be new species or part of a complex of species within each genus, and requiring more detailed taxonomic revisions. Nine species are the first records for the Piquiri river basin.

INTRODUCTION

The Perobas Biological Reserve (Reserva Biológica das Perobas or "Rebio das Perobas") is a Federal Conservation Unit, and comprises the largest remnant forest in northwestern Paraná, Brazil. The reserve covers an area of 8,716 ha located in a region of contact between Semideciduous Seasonal Forest and Mixed Ombrophilous Forest, two physiognomies of the Atlantic Forest *sensu lato* existing in Paraná State (Joly *et al*. 1999). It is considered one of the priority areas for protection of these types of forest formations (ICMBio 2012). The Rebio das Perobas is also part of the Atlantic Forest Biosphere Reserve and part of the UNESCO Man and the Biosphere program, as a core zone, for which the main objective is conservation of biodiversity (Lino *et al*. 2009). With endangered status, the Atlantic Forest is one of the world's 25 biodiversity hotspots that support a very high species richness and endemism (Tabarelli *et al*. 2005; Abell *et al*. 2008; Nogueira *et al*. 2010).

The Rebio das Perobas is located at the junction of two major watersheds of the Paraná State (Ivaí and Piquiri), contributing to the formation of numerous small watercourses, with preserved headwaters and many protected springs. The rivers that drain these basins are among the main tributaries of the Paraná River, which is the second-largest drainage system in South America, with an area of 3.2 million km^2 (Lowe-McConnell 1999). In the state of Paraná, the drainage areas related to the Upper Paraná River basin occupies about 128,507 km^2 (Parolin *et al*. 2010), in which about 400 species of fishes are reported (Abilhoa and Duboc, 2004; Langeani *et al*. 2007; Cetra *et al*. 2012).

Biological inventories in Conservation Units are crucial for the planning and establishment of management strategies by governmental and non-governmental organizations (Aquino *et al*. 2009). Although the freshwater fishes of the Upper Paraná River have been relatively well known (Agostinho *et al*. 1997; 2007), this information has been concentrated in a few parts of this large area (Langeani *et al*. 2007; Agostinho *et al*. 2008; Súarez, 2008). Studies conducted by Maier *et al*. (2008) in the Barra Bonita River and by Araújo *et al*. (2011) in Itiz stream, both tributaries of the Ivaí River, indicated the presence of additional new species. These findings demonstrated that by increasing sampling efforts, mainly in the small tributaries, additional and new species could still be recorded.

The objective of the present study was to develop a taxonomic list of the fish fauna in streams that arise in or flow through the Perobas Biological Reserve, in order to provide a basis for the establishment of strategies for conservation of these aquatic systems.

MATERIALS AND METHODS

Study area

The present study was conducted in streams of the Perobas Biological Reserve in northwestern Paraná, in the municipalities of Cianorte and Tuneiras do Oeste, near the conjunction of two major river basins of the state, the Ivaí and Piquiri rivers (Figure 1). Both rivers are tributaries of the left bank of the Paraná River. The northern and eastern portions of this conservation unit lie within the sub-basin of the Índios River, a tributary of the left bank of the Ivaí. The Ivaí River flows through a stretch of 798 km, draining an area of 35,845 km^2 from its source to its mouth at the Paraná River. The southern and western portions of the Rebio Perobas are drained by the Mouro River, which arises within the Rebio and is a tributary of the right bank of the Goio-erê River. The Piquiri River hydrographic basin has a drainage area of 31,000 km^2. The headwaters are

located in the São João Mountains, and the river flows for 485 km until it discharges into the Paraná River. The most important tributaries of the right margin are the Goio-erê, Tricolor and Cantú rivers (Parolin *et al*. 2010).

The land in the vicinity of the Perobas Biological Reserve is mainly devoted to agriculture, where the most important crops are sugarcane, soybeans, cassava and corn (maize), as well as pastures. Potential environmental impacts are increasing soil erosion, siltation of water resources, and pesticide contamination. The main physical characteristics and geographical coordinates are shown in Table 1 and Figure 2.

Fish sampling

Fishes were collected using two methods: the electrofishing technique in five sampling reaches in four streams of third to fourth order, located inside and surrounding the Perobas Biological Reserve, quarterly from December 2010 to March 2012 (Table 1, Figures 1 and 2). We used electrofishing with three passes of 40 minute in extensions of 50 meters at each reach. The electrofishing equipment was powered by a portable generator (Honda, 2.5 kW, 220 V, 3 –4 A) connected to a DC transformer, with two electrified net rings (anode and cathode). Output voltage varied from 400 to 600 V. For both types of sampling we installed blocking nets (mesh size 0.5 mm) at the ends of each reach to prevent any fish escaping. In the Índios River, downstream reach (Table 1, Figures 1 and 2), that had depth greater than 1.5 m, we made a single sampling in December 2010 using gillnets with simple (2.4, 3, 4, 5, 6 and 7 cm between non-adjacent knots) and trammel nets (three layers; internals meshes of 6 and 7 cm), all 15 m long. Gill nets were set for 24 hours, with checks in the morning (08:00 h), afternoon (16:00 h) and evening (22:00 h).

After sampling, the collected specimens were sacrificed in a solution of clove oil (Eugenol, 2 drops per litre; *cf.* American Veterinary Medical Association 2001), and fixed in 10% formalin. Fish were collected under the license of the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) (Process numbers 24196-1/22/06/2010 - 27252-1/02/03/2011). Specimens were identified in the laboratory according to Graça and Pavanelli (2007), and then preserved in 70% alcohol. Voucher specimens were deposited in the fish collection of Nupélia (Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura), of the State University of Maringá, Brazil.

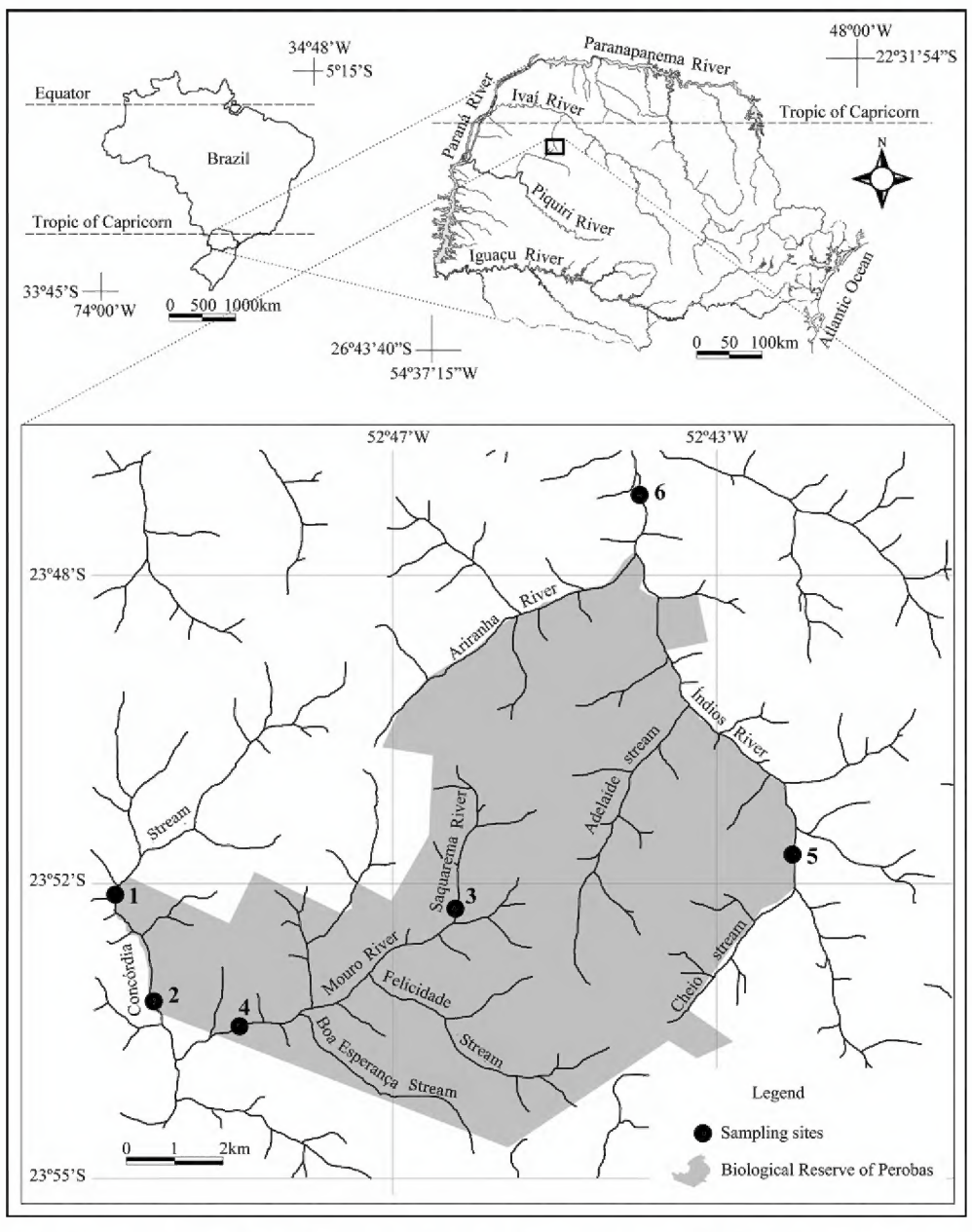

Figure 1. Map of Rebio das Perobas streams, Ivaí and Piquiri River basins, Paraná, Brazil, indicating sampling sites.

Results and Discussion

At the six sites sampled, 2628 individual fish were collected, belonging to 34 species in 25 genera, 13 families and six orders (Table 2). Only *Poecilia reticulata* Peters 1859 and *Erythrinus erythrinus* (Bloch and Schneider 1801) were considered non-native species, and 10 species are probably undescribed. Based on species number, the most important order was Siluriformes, with 14 species (41.2%), followed by Characiformes with 11 species (32.4%). Loricariidae and Characidae were the families with the largest number of species (Table 2). The predominance of Characiformes and Siluriformes is a common pattern in the Neotropics (Lowe-McConnell 1999; Buckup *et al*. 2007), and has also been found in several surveys of the fish fauna in streams of different basins in Paraná (Maier *et al*. 2008; Cunico *et al*. 2009; Gubiani *et al*. 2010a; Araújo *et al.* 2011).

This survey found a higher proportion of Siluriformes, especially due to the presence of several species of armored catfishes (Loricariidae) and small catfishes (Heptapteridae). The relatively high richness of Siluriformes is correlated with the characteristics of the habitat. The higher numbers of environments with riffles and rocks bottoms, as well as streamside vegetation (grasses) submerged in some reaches, favors the occurrence of individuals belonging to this taxon (Súarez *et al*. 2007; Araújo *et al*. 2011; Pagotto *et al*. 2011). The other orders recorded (Gymnotiformes, Cyprinodontiformes, Perciformes and Synbranchiformes) are widely distributed in Brazilian hydrographic basins, and generally show lower species diversity (Langeani *et al*. 2007; Oliveira *et al*. 2009; Cetra *et al*. 2012; Volcan *et al*. 2012).

Surveys in the main channel of the Piquiri River were conducted by Agostinho *et al*. (1997; 2004), who recorded 57 fish species; and by Gubiani *et al*. (2010b), who found 69 species. In our study, were caught nine species that did not appear in three previous surveys. Thus, are new records for the river basin Piquiri the following species: *Characidium gomesi* Travassos 1956, *Callichthys callichthys* (Linnaeus 1758), *Cetopsorhamdia iheringi* Schubart and Gomes 1959, *Corydoras aeneus* (Gill 1858), *Imparfinis borodini* Mees and Cala 1989, *Phalloceros harpagos* Lucinda 2008, *Poecilia reticulata*, *Synbranchus marmoratus* Bloch 1795 and *Cichlasoma paranaense* Kullander 1983. These additions are related to the collecting equipment and depth of the environments, since the above-mentioned investigators used gillnets, while the present study used

Table 1. Physical characteristics of the sampled sites in Rebio das Perobas, Ivaí and Piquiri River basins, Paraná, Brazil. Stream order according to Strahler (1957).

REACHES	STREAMS	ORDER	PREDOMINANT SUBSTRATE	RIPARIAN VEGETATION	CHANNEL PHYSIOGRAPHY	OBSERVATIONS
R1	Concórdia Stream	3rd	Sandy, with fallen tree trunks and leaf litter	Trees and bushes on both banks. Extensive stands of grasses, especially along left bank	Some stretches of riffles, a few pools up to 0.5 m deep, and meanders	Impacted gallery forest on right bank, streambed silted, with sugarcane fields and pastures at the headwaters
R2	Concórdia Stream	3rd	Sandy/ rocky and pebbles in stretches of the left bank	Trees and bushes on both banks, with submerged roots of terrestrial plants, principally pteridophytes	Lateral stretch with rocky bottom, a few meanders and pools up to 1.2 m deep	Streambed heavily silted, bank eroding, near the highway and with trails and people passing to fish or hunt
R3	Saquarema River	2nd	Sandy, stretches with litter	Trees and bushes, continuous with adjacent forest. Thick bamboos overhanging the riverbed	No riffles, and two pools 0.70 m deep, few meanders	More-preserved point located completely within the Reserve, with bamboos and fallen leaves
R4	Mouro River	4th	Sandy, stretches with gravel, pebbles and litter	Right bank with trees, left bank with bushes and thick stands of grasses	Stretches of riffles with rocky and sandy bottom, meanders, some pools up to 0.80 m deep	Bed silted, left bank eroding, near the highway and with trails and people passing
R5	Índios River	3rd	Rocky/sandy, with fallen tree trunks and litter	Trees on left bank, continuous with adjacent forest. Right bank with 30- to 50-m wide tree belt, surrounded by pastures	Stretches of riffles with rocky bottom, followed by sandy bottom, some meanders, pools up to 0.60 m deep and fallen branches in the river and along its banks	Well-preserved stretch, although with streambed silting, several microhabitats along the banks (branches, trunks, roots)
R6	Índios River	4rd	Sandy/clayey	Banks of wetland about 40 m long, covered by grasses	Stretch with a channel with strong current, and a pond on left bank	Point located near a bridge, with presence of trash, silting, and several hunting and fishing trails along the banks.

only electrofishing, and our samples were taken only in the headwater streams. Thus, in this context, our study constitutes the first listing for streams in the Piquiri River basin, one of the least-inventoried basins in the state and more threatened by future construction of dams (ANEEL 2009).

With respect to the three constant species in our list belonging to the genus *Gymnotus*, two of them were probably previously recorded as *Gymnotus carapo* Linnaeus 1758. According to Graça and Pavanelli (2007), specimens of *Gymnotus inaequilabiatus* (Valenciennes 1839) and *Gymnotus sylvius* Albert and Fernandes-Matioli 1999 may have been erroneously identified as *G. carapo*. Thus, the occurrence of these species in the region may be natural. In any event, Graça and Pavanelli (2007) also did not discard the hypotheses that the occurrence of these two species, as with *Gymnotus pantanal* Fernandes, Albert, Daniel-Silva, Lopes, Crampton and Almeida-Toledo 2005, may be the result of inter-basin movement, through the use of specimens as live bait or also through invasion from the Upper Paraná River after the Itaipu Reservoir was formed. A similar situation with respect to identification occurs in the case of genus *Hoplias*. According to Pazza and Júlio Júnior (2003), three cytotypes occur in the upper Paraná River region, and specimens of these were all previously identified as *Hoplias* aff. *Malabaricus* (Bloch 1794). In our study, we differentiated them as *Hoplias* sp. 2 and *Hoplias* sp. 3, according to Graça and Pavanelli (2007).

The fish fauna was characterized by small-sized specimens; about 75% had a mean standard length (SL) lower than 150 mm. Only *Crenicichla britskii* Kullander 1982, *Gymnotus inaequilabiatus*, *G. pantanal*, *G. sylvius*, *Hypostomus ancistroides* (Ihering 1911), *Hoplias* sp. 2, *Hoplias* sp. 3, *Rhamdia quelen* (Quoy and Gaimard 1824) and *Symbranchus marmoratus* reached greater lengths. Castro (1999) stated that the predominance of small-sized species is the only general pattern found for the ichthyofauna of streams in the Neotropical region. The species generally show a strong dependence on riparian vegetation, and have little or no commercial value (Cetra *et al*. 2012). However, they are important in the trophic relationships of these ecosystems.

Of the total species collected, only four were common to all the sampling reaches: *Astyanax altiparanae* Garutti

Figure 2. Examples of sampled localities in Rebio das Perobas, Ivaí and Piquiri River basins, Paraná, Brazil. 1) Concórdia Stream upstream; 2) Concórdia Stream downstream; 3) Saquarema River; 4) Mouro River; 5) Índios River upstream; 6) Índios River downstream.

and Britski 2000, *Astyanax* aff. *paranae* Eigenmann 1914, *H. ancistroides* and *R. quelen*. The majority of these species were recorded in streams of different basins, indicating a wide geographical distribution (Castro *et al*. 2003; Galves *et al*. 2007; Súarez and Lima-Junior 2009; Oyakawa and Menezes 2011; Casatti *et al*. 2012). *Cyphocharax modestus* (Fernández-Yépez 1948), *Characidium* aff. *zebra* Eigenmann 1909, *E. erythrinus*, *Hoplias* sp. 2, *C. britskii* and *Geophagus brasiliensis* (Quoy and Gaimard 1824) were recorded exclusively in the Ívai River basin. Except for *C.* aff. *zebra*, the remaining species were caught in gillnets at point 6 (Índios River), which is deeper, explaining the presence of larger-sized species. Considering that *C. modestus* can make short reproductive migrations

Table 2. List of fish and their respective occurrences at sampling reaches of the Rebio das Perobas, Ivaí and Piquiri River basin, state of Paraná, Brazil. Systematic positions were based on Reis *et al.* (2003).

TAXON	COMMON NAME	1	2	3	4	5	6	VOUCHERS
CHARACIFORMES								
Paradontidae								
Parodon nasus Kner 1859	"canivete"				x			NUP 14654
Curimatidae								
Cyphocharax modestus (Fernández-Yépez 1948)	"saguiru"						x	NUP 11730
Crenuchidae								
Characidium aff. *zebra* Eigenmann 1909	"mocinha"					x		NUP 14644
Characidium gomesi Travassos 1956	"charutinho"	x	x	x	x	x		NUP 11709, 11718, 14645
Characidae								
Astyanax aff. *paranae* Eigenmann 1914	"lambari"	x	x	x	x	x	x	NUP 11716, 11708, 11708
Astyanax altiparanae Garutti and Britski 2000	"lambari-do-rabo-amarelo"	x	x	x	x	x	x	NUP 11711, 11734
Bryconamericus stramineus Eigenmann 1908	"lambari"		x					NUP 14630
Oligosarcus paranensis Menezes and Géry 1983	"saicanga"			x				NUP 14646
Erythrinidae								
Erythrinus erythrinus (Bloch and Schneider 1801)	"jejú"						x	NUP 11729
Hoplias sp. 2	"traíra"						x	NUP 11740
Hoplias sp. 3	"traíra"		x					NUP 14626
SILURIFORMES								
Trichomycteridae								
Trichomycterus sp. 1	"candiru"	x	x	x	x	x		NUP 11712, 11707, 11726
Trichomycterus sp. 2	"candiru"	x	x	x	x	x		NUP 14648
Trichomycterus sp. 3	"candiru"	x	x	x	x	x		NUP 11703, 11727
Callichtyidae								
Callichthys callichthys (Linnaeus 1758)	"tamboatá ou camboja"			x	x			NUP 14647, 14649
Corydoras aeneus (Gill 1858)	"tamboatazinho"		x	x	x		x	NUP 11714, NUP 11726
Loricariidae								
Ancistrus sp.	"cascudinho-barbudo"	x	x		x	x		NUP 11710, 11706, 11720
Hisonotus sp.	"cascudinho limpa-vidro"	x	x	x	x	x		NUP 11715, 11701, 14625
Hypostomus ancistroides (Ihering 1911)	"cascudo"	x	x	x	x	x	x	NUP 11733, 11738, 14633,14638
Hypostomus sp. 1	"cascudo"	x				x		NUP 14622, 14623, 14627
Hypostomus sp. 2	"cascudo"		x		x	x		NUP 14629
Neoplecostomus sp.	"cascudinho"	x	x					NUP 14631
Heptapteridae								
Cetopsorhamdia iheringi Schubart and Gomes 1959	"bagrinho"	x	x		x			NUP 14636, 14636, 14651
Imparfinis borodini Mees and Cala 1989	"bagrinho"	x	x		x			NUP 14624, 14635
Rhamdia quelen (Quoy and Gaimard 1824)	"bagre", "jundiá"	x	x	x	x	x	x	NUP 11717
GYMNOTIFORMES								
Gymnotidae								
Gymnotus sylvius Albert and Fernandes-Matioli 1999	"morenita"	x	x	x	x	x		NUP 11713, 11725
Gymnotus inaequilabiatus (Valenciennes 1839)	"morenita"	x	x			x	x	NUP 11705, 11724
Gymnotus pantanal Crampton and Almeida-Toledo 2005	"morenita"		x					NUP 14628
CYPRINODONTIFORMES								
Poeciliidae								
Phalloceros harpagos Lucinda 2008	"barrigudinho", "guaru"	x	x			x		NUP 11719, 14650
Poecilia reticulata Peters 1859	"barrigudinho", "guaru"		x					NUP 14632
SYNBRANCHIFORMES								
Synbranchidae								
Synbranchus marmoratus Bloch 1795	"pirambóia ou muçum"	x	x		x	x		NUP 11702
PERCIFORMES								
Cichlidae								
Crenicichla britskii Kullander 1982	"joaninha"						x	NUP 11732
Cichlasoma paranaense Kullander 1983	"acará"	x			x		x	NUP 11728
Geophagus brasiliensis (Quoy and Gaimard 1824)	"acará"						x	NUP 11737

(Graça and Pavanelli 2007) and that the many individuals caught (191 in a single collection) showed mature gonads (personal observation), we can suggest that the Índios River is a spawning ground for this species. Thus, it is appropriate to emphasize the importance of this river as a biodiversity corridor, interconnecting the water drainage net on the north and east sides of the Rebio das Perobas with the Ivaí River. This information becomes even more important when one considers that projects to construct small electrical-energy production centers (PCHs) exist on this river. On the other hand, 10 taxa were recorded only at the points belonging to affluent streams in the Piquiri River basin, which represents about 30% of the total richness. These results indicate differences in the species composition among the streams of the basins of the Piquiri and Ivaí rivers.

Notably, of the 34 species collected, 10 have unresolved taxonomy (*i.e.*, are still undescribed and lack a specific epithet), and may be new species or part of a species complex within each genus, and therefore require more-detailed taxonomic revisions. These results confirm the statements of Langeani *et al*. (2007) and Maier *et al*. (2008) that, although the fish fauna of the Upper Paraná River is among those most intensively investigated, the number of presently known species is far from representing the reality, especially in stream and headwater environments. This lacuna, allied to the status of the Atlantic Forest as one of the two recognized biodiversity hotspots in Brazil, with a large number of hydrographic basins subject to harmful human actions, emphasizes the importance of surveys and studies of distribution in Conservation Units. Nogueira *et al*. (2010) suggested that the number of threatened species of freshwater fishes in Brazil is at least four times higher than presently indicated by the world and national red lists.

The number of species in this checklist may well undergo changes with respect to the valid species names. Nevertheless, this is the first list of the fish fauna from this Conservation Unit, one of the few areas with native vegetation remaining in northern and northeastern Paraná. We hope that the checklist will serve as a reference to aid in the management of the Perobas Biological Reserve, in environmental education programs for the surrounding communities, and as a basis for comparisons for present and future studies of the ecology of fishes of streams.

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